A STATISTICAL STUDY OF MERCURIAN CRATER CLASSES APPLIED TO THE EMPLACEMENT OF THE INTERCRATER PLAINS

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Studies of crater classes have been few in number and disappointing in value. Perhaps this stems from the difficulties in statistically treating a nonstationary, multivariate data set, or from the propensity to treat all crater data phenomenologically rather than statistically. In either case, recent statistical innovations (Aitchison, 1982) afford a new opportunity to reconsider the value of crater classes.

Two principal processes have been invoked for emplacement of the intercrater plains: 1) basin ejecta and autochthonous surface materials reworked by that ejecta or 2) volcanic flows. Previous studies directed at discriminating among these two plausible origins have used two broad approaches: analysis of crater population statistics, and assessment of diagnostic landforms. For several reasons, neither approach has substantiated the origin of the plains units nor persuaded many to alter their initial view point. Therefore, we undertook a new approach: the multivariate statistical analysis of crater-class. The results of the analysis constrain the formative process of the intercrater plains units to have affected craters on both terrains in a similar manner. Any emplacement process brief in temporal extent (compared to the period of late heavy bombardment), such as emplacement of ejecta from a single event or a brief period of extensive volcanism, violates this constraint.

In order to apply standard crater statistical methodologies to the comparison of the two terrains, class by class and crater size by crater size, one must achieve good counting statistics. That is, the number of craters in a given class in a given diameter interval should be as large as possible so that sampling errors (that are equal to the square root of the number of craters counted) are as small as possible. In order to achieve this one must include large expanses of each terrain type in the study. But if the different areas have not experienced the emplacement process in a substantially identical manner, then combining areas may blur the signature of the process beyond recognition. Therefore, one would ideally like to sample small regions to obtain a homogeneous crater population, but large regions to obtain adequate sampling statistics. Faced with this problem, the most common approach has been to amalgamate the data from different regions and simply hope that heterogeneities would not frustrate the analysis. But amalgamation of samples clearly has traps in terms of both diluting the homogeneity of the signatures and reproducing locations of terrain boundaries.

The densely cratered terrains of Mercury occur in widely separated, poorly defined patches that are not constrained to constitute a

homogeneous data set. However, each area has only a relatively small number of craters. This data set begs for a new multivariate approach to the statistical treatment of craters.

We have classified craters in eleven regions of densely cratered plains and eleven regions of intercrater plains into four classes based on their degree of filling (from 1 = pristine to 4 = totally filled). The percentage of craters in each class in each region was then recorded, thus eliminating the problem of nonstationarity--but introducing the problem of induced correlations. Induced correlations arise in percentage data because as the percentage of craters in one class increases, the percentage in at least one other class must decrease--without the necessary intervention of any geologic process. This is commonly alluded to as King's law: "Some of it plus the rest of it equals all of it."

By standard statistical analyses, the correlation matrix (below) formed from percentage data seems to indicate a very significant (beyond the 1% level) negative correlation between class 2 and class 4 craters. A simple story could be constructed to account for this--a tale that makes excellent geologic sense, but, in fact, is no more than hand flailing if not supported by the statistical attributes of the data. In fact, when the algorithm suggested by Aitchison (1982) and implemented by Woronow and Butler (1986) is applied, this correlation is found to lack significance--no significant correlations (at the 5% level) exist in these data. Additional tests of the data divided into diameter intervals and terrain types also reveal no significant correlations. This implies that the crater classes on both terrains responded equally to, or independently of, the emplacement of the intercrater plains.

Among the processes that satisfy this substantial constraint would be a protracted period of volcanic emplacement spanning much of the period of late heavy bombardment, with the craters on both terrains being affected in a similar manner (although not necessarily to the same degree) on both terrains and in all areas studied here. Alternatively, the filling process could be linked to the impact bombardment itself so that craters would progress through the classes in proportion to the cumulative intensity of the bombardment on both surfaces. Processes that cannot account for the emplacement of the intercrater plains include short pulses of emplacement of volcanic deposits or of basin ejecta.

Aitchison, J. (1982). The statistical analysis of compositional data sets. J. Roy. Statis. Soc., **B44**, 139-177.

Woronow, A. and Butler, J.C. (1986). Complete subcompositional independence testing of closed data. Comp. & Geosci. 12, 267-280.

Correlation Matrix for Percentage Data

	CLASS II	CLASS III	CLASS IV	TOTAL
CLASS I	-0.11	-0.39	-0.20	-0.09
CLASS II		-0.25	-0.63	-0.13
CLASS III			-0.37	-0.25
CLASS IV				-0.04